Claims:

1. A processing cell for an electro-chemical deposition system, comprising:

a head assembly configured to support a wafer, the head assembly including a cathode;

an electrolyte container configured to hold a fluid electrolyte therein and having an anode disposed within the container; and

a power supply in electrical communication with the cathode and the anode, the power supply being configured provide a pulsed power waveform to the cathode and anode.

2. The processing cell of claim 1, wherein the power supply is configured to generate a pulsed voltage waveform having a sequence of large magnitude voltage pulses and small magnitude voltage pulses.

3. The processing cell of claim 2, wherein the large magnitude voltage pulses have a voltage of between about 2 volts to about 15 volts.

4. The processing cell of claim 2, wherein the large magnitude voltage pulses have a voltage of between about 5 volts to about 10 volts.

5. The processing cell of claim 2, wherein the small magnitude voltage pulses have a voltage of between about 0 volts to about 2 volts.

6. The processing cell of claim 2, wherein the small magnitude voltage pulses have a voltage of between about 0.3 volts to about 1.5 volts.

7. The processing cell of claim 2, wherein the small magnitude voltage pulses have a voltage of between about negative 0.1 volts to about negative 2 volts.

8. The processing cell of claim 2, wherein the large magnitude voltage pulses are configured to supply a current density to the cathode of between about 8 milliamps per cubic centimeter and about 50 milliamps per cubic centimeter.

9. The processing cell of claim 2, wherein the large magnitude voltage pulses are configured to supply a current density to the cathode of between about 16 milliamps per cubic centimeter and about 32 milliamps per cubic centimeter.

10. The processing cell of claim 1, wherein the power supply is configured to generate a predetermined number of cycles of large magnitude voltage pulses and small magnitude voltage pulses.

11. The processing cell of claim 10, wherein the predetermined number of cycles is between about 5 cycles and about 50 cycles.

12. The processing cell of claim 1, wherein the cathode comprises a cathode contact ring.

13. The processing cell of claim 12, wherein the cathode contact ring includes a plurality of contacts radially positioned about the cathode contact ring, each of the plurality of contacts being configured to conduct electrical energy from the power supply to a seed layer to be plated on a wafer.

14. The processing cell of claim 1, wherein the anode further comprises:
a consumable anode plate; and
a permeable encapsulation member enclosing the consumable anode plate.

15. The processing cell of claim 1, wherein the pulsed power waveform further comprises at least one of a square voltage waveform, a saw tooth waveform, a triangular waveform, and a sinusoidal waveform.

16. The processing cell of claim 2, wherein the large magnitude voltage pulses have a duration of about 50 milliseconds to about 500 milliseconds.

17. The processing cell of claim 2, wherein the small magnitude voltage pulses have a duration of about 50 milliseconds to about 500 milliseconds.

18. An apparatus for electro-chemically depositing a metal onto a substrate, comprising:

a head assembly comprising:

a cathode; and

a wafer holder disposed above the cathode;

a process kit disposed below the head assembly, comprising :

an electrolyte container configured to receive and maintain a fluid electrolyte therein; and

an anode disposed in the electrolyte container;

a power supply in electrical communication with the cathode and the anode, the power supply being configured to provide a varying amplitude electrical signal to the anode and cathode.

19. The apparatus of claim 18 wherein the cathode comprises a cathode contact ring.

20. The apparatus of claim 19 wherein the cathode contact ring further comprises a wafer seating surface having a plurality of conductive wafer contact pads extending therefrom for conducting electrical current from the power supply to a seed layer to be plated.

21. The apparatus of claim 18, wherein the anode comprises:

a consumable anode plate; and

a permeable encapsulation member enclosing the consumable anode plate.

22. The apparatus of claim 18, wherein the power supply is configured to generate a cyclical pulsed voltage waveform of large magnitude voltage pulses and small magnitude voltage pulses.

23. The apparatus of claim 18, wherein the cyclical pulsed voltage waveform of large magnitude voltage pulses and small magnitude voltage pulses further comprises at least one of a square voltage waveform, a saw tooth waveform, a triangular waveform, and a sinusoidal waveform.

24. The apparatus of claim 22, wherein the large magnitude voltage pulses have a voltage of between about 2 volts to about 15 volts.

25. The apparatus of claim 22, wherein the large magnitude voltage pulses have a voltage of between about 5 volts to about 10 volts.

26. The apparatus of claim 22, wherein the small magnitude voltage pulses have a voltage of between about 0 volts to about 2 volts.

27. The apparatus of claim 22, wherein the small magnitude voltage pulses have a voltage of between about 0.3 volts to about 1.5 volts.

28. The apparatus of claim 22, wherein the small magnitude voltage pulses have a voltage of between about negative 0.1 volts to about negative 2 volts.

29. The apparatus of claim 22, wherein the large magnitude voltage pulses are configured to supply a current density to the cathode of between about 8 milliamps per cubic centimeter and about 50 milliamps per cubic centimeter.

30. The apparatus of claim 22, wherein the large magnitude voltage pulses are configured to supply a current density to the cathode of between about 16 milliamps per cubic centimeter and about 32 milliamps per cubic centimeter.

31. The apparatus of claim 22, wherein the power supply is configured to generate a predetermined number of cycles of large magnitude voltage pulses and small magnitude voltage pulses.

32. The apparatus of claim 30, wherein the predetermined number of cycles is between about 5 cycles and about 50 cycles.

33. A method for electroplating metal into sub-quarter micron integrated circuit features, comprising:

providing an electrolyte container configured to receive and maintain a fluid electrolyte therein, the electrolyte container having an anode disposed within the electrolyte container;

providing a head assembly positioned above the electrolyte container, the head assembly including a wafer holder for supporting a wafer and a cathode;

positioning a wafer in the electrolyte container in contact with the fluid electrolyte; and

applying a varying amplitude waveform to the cathode and anode in an electroplating process.

34. The method of claim 33, wherein applying a varying amplitude waveform further comprises applying a cyclical waveform having a small magnitude voltage pulse and a large magnitude voltage pulse.

35. The method of claim 34, wherein applying the cyclical waveform further comprises applying the cyclical waveform between about 5 cycles and about 50 cycles.

36. The method of claim 32, wherein the varying amplitude waveform further comprises at least one of a square voltage waveform, a saw tooth voltage waveform, a triangular voltage waveform, and a sinusoidal voltage waveform.

37. The method of claim 34, wherein the large magnitude voltage pulses have a voltage of between about 2 volts to about 15 volts.

38. The method of claim 34, wherein the large magnitude voltage pulses have a voltage of between about 5 volts to about 10 volts.

39. The method of claim 34, wherein the small magnitude voltage pulses have a voltage of between about 0 volts to about 2 volts.

40. The method of claim 34, wherein the small magnitude voltage pulses have a voltage of between about 0.3 volts to about 1.5 volts.

41. The method of claim 34, wherein the small magnitude voltage pulses have a voltage of between about negative 0.1 volts to about negative 2 volts.

42. The method of claim 34, wherein the large magnitude voltage pulses are configured to supply a current density to the cathode of between about 8 milliamps per cubic centimeter and about 50 milliamps per cubic centimeter.

43. The method of claim 34, wherein the large magnitude voltage pulses are configured to supply a current density to the cathode of between about 16 milliamps per cubic centimeter and about 32 milliamps per cubic centimeter.

44. The method of claim 34, wherein the large magnitude voltage pulses have a duration of about 50 milliseconds and about 500 milliseconds.

45. The method of claim 34, wherein the small magnitude voltage pulses have a duration of about 50 milliseconds and about 500 milliseconds.

46. A method for electroplating metal, comprising:
providing an electrolyte having an anode disposed therein;
providing a cathode in electrical communication with a wafer to be plated; and
applying a varying amplitude voltage waveform to the cathode and anode in a plating process.

47. The method of claim 46, wherein applying a varying amplitude waveform further comprises applying a cyclical waveform having a small magnitude voltage pulse and a large magnitude voltage pulse.

48. The method of claim 46, wherein applying the cyclical waveform further comprises applying the cyclical waveform between about 5 cycles and about 50 cycles.

49. The method of claim 46, wherein the varying amplitude waveform further comprises at least one of a square voltage waveform, a saw tooth voltage waveform, a triangular voltage waveform, and a sinusoidal voltage waveform.

50. The method of claim 46, wherein the large magnitude voltage pulses have a voltage of between about 2 volts to about 15 volts.

51. The method of claim 46, wherein the large magnitude voltage pulses have a voltage of between about 5 volts to about 10 volts.

52. The method of claim 46, wherein the small magnitude voltage pulses have a voltage of between about 0 volts to about 2 volts.

53. The method of claim 46, wherein the small magnitude voltage pulses have a voltage of between about 0.3 volts to about 1.5 volts.

54. The method of claim 46, wherein the small magnitude voltage pulses have a voltage of between about negative 0.1 volts to about negative 2 volts.

55. The method of claim 46, wherein the large magnitude voltage pulses are configured to supply a current density to the cathode of between about 8 milliamps per cubic centimeter and about 50 milliamps per cubic centimeter.

56. The method of claim 46, wherein the large magnitude voltage pulses are configured to supply a current density to the cathode of between about 16 milliamps per cubic centimeter and about 32 milliamps per cubic centimeter.

57. The method of claim 46, wherein the large magnitude voltage pulses have a duration of about 50 milliseconds and about 500 milliseconds.

58. The method of claim 46, wherein the small magnitude voltage pulses have a duration of about 50 milliseconds and about 500 milliseconds.